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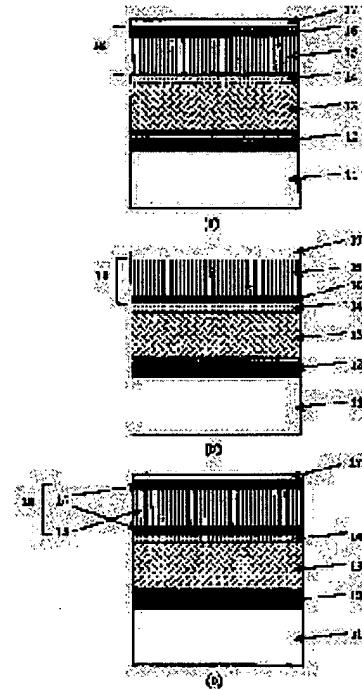
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(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM AND MAGNETIC STORAGE DEVICE

(57) Abstract:

PROBLEM TO BE SOLVED: To provide a perpendicular magnetic recording medium and a magnetic storage device having excellent low noise characteristics and stability of recording magnetization and suitable for super high density magnetic recording.

SOLUTION: In the perpendicular magnetic recording medium, a perpendicular magnetic film 18 is used, provided with a super thin CoCrPt alloy magnetic layer 16 having low Cr concentration and high Pt concentration as any one of a lower or an upper layer of a CoCr alloy perpendicular magnetic film 15 having high Cr concentration or the magnetic layers 16 as both of the lower and the upper layers of the magnetic film 15, and a polycrystalline thin film consisting of a non-cylindrical structure or an amorphous material is used as a backing magnetic layer whose magnetic domain structure is controlled by a magnetic domain fixing layer 12.



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CLAIMS**[Claim(s)]**

[Claim 1] The aforementioned perpendicular magnetic anisotropy films are vertical-magnetic-recording media by which either or vertical both the layers of the lower layer or the upper layer are characterized by being the CoCrPt alloy magnetic film of the composition as which the range of 8-15at%Cr of 10nm or less of thickness and 15-25at%Pt was chosen including the two-layer magnetic film from which composition differs in the vertical-magnetic-recording medium which prepared perpendicular magnetic anisotropy films through the lining soft-magnetism layer on the substrate at least.

[Claim 2] It is the vertical-magnetic-recording medium characterized by the aforementioned perpendicular magnetic anisotropy films having Ru layer, CoRu alloy layer, or CoCrRu alloy layer of the range of 0.5-1nm thickness between the aforementioned CoCrPt alloy magnetic film and other magnetic films in a vertical-magnetic-recording medium according to claim 1.

[Claim 3] The vertical-magnetic-recording medium characterized by having an antiferromagnetism layer in a vertical-magnetic-recording medium according to claim 1 or 2 in the lower part which separated the interval of 10-100nm from the lowest side of the aforementioned perpendicular magnetic anisotropy films, and having a soft-magnetism layer between the aforementioned antiferromagnetism layer and the aforementioned perpendicular magnetic anisotropy films.

[Claim 4] Magnetic storage characterized by using a vertical-magnetic-recording medium according to claim 1 or 2 as the aforementioned magnetic-recording medium in magnetic storage equipped with a magnetic-recording medium, the ring-type or single magnetic pole type head for magnetic recording, and a magnetoresistance-effect type, a spin bulb type or the magnetic tunnel type head for signal regeneration.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] The reproduction noise of this invention is small and it is related with overly suitable vertical-magnetic-recording medium and magnetic storage excellent in the stability of record magnetization for high-density magnetic recording.

[0002]

[Description of the Prior Art] In order to improve track recording density in the magnetic-recording method within a field used practical now, it is necessary to make small the residual magnetization (Br) of a magnetic film and the product ($Br \cdot t$) of magnetic thickness (t) which are a record medium, in order to decrease the influence of an anti-magnetic field at the time of record, and to increase coercive force. Moreover, in order to decrease the medium noise generated from magnetization changes, while carrying out orientation of the easy axis of a magnetic film in parallel with a substrate side, the diameter of crystal grain needs to be controlled.

[0003] As a magnetic film for the magnetic recording within a field, Co is made into a principal component and Co alloy thin film which added Cr, Ta, Pt, Rh, Pd, Ti, nickel, Nb, Hf, etc. to this is used. The material of roppo dense grillage construction (henceforth hcp structure) is mainly used for Co alloy which constitutes a magnetic thin film. The c axis of this crystal has an easy axis in the <00.1> direction, and carries out orientation of this easy axis to field inboard. In order to control the crystal stacking tendency and particle size of a magnetic thin film, the ground layer for structure control is formed between a substrate and a magnetic film. As a ground layer, Cr is made into a principal component and the material which added Ti, Mo, V, W, Pt, Pd, etc. to this is used. A magnetic thin film is formed by the vacuum deposition method or the sputtering method. As described above, in order to make a medium noise small in the magnetic recording within a field and to improve track recording density, it is required to make small the residual magnetization (Br) of a magnetic film and the product of magnetic thickness (t), to make thickness of a magnetic film thin to 20nm or less for this reason, and to make the diameter of crystal grain detailed to 10-15nm. However, by the medium which turned such magnetic crystal grain minutely, there is a very serious problem that record magnetization decreases by heat fluctuation, and it has been the obstacle of high-density record.

[0004] The anti-magnetic field in the boundary of a record bit becomes small, on the other hand, vertical magnetic recording is a magnetic-recording method which forms a magnetic domain so that an adjacent record bit may become anti-parallel mutually at right angles to record intermedia dignify, and it is [there is an advantage to which magnetization is easy to be kept stable as high-density record, and] one of the leading meances of high-density magnetic recording. In a vertical magnetic recording, magnetic thickness can be thickened compared with the magnetic recording within a field, and there is an advantage which can hold stably record magnetization in a high recording density field especially. In order to improve track recording density by the vertical magnetic recording, it is required to decrease the medium noise generated from the magnetic domain of the unordered structure formed in the interior of a record bit and a magnetization transition region. for this reason -- being alike -- while carrying out orientation of the easy axis of a magnetic film at right angles to a substrate side, it is required to make orientation distribution of an easy axis small and to control the diameter of crystal grain

[0005] There are a monolayer vertical-magnetic-recording medium which formed perpendicular magnetic anisotropy films through the structure control layer on the substrate, and a two-layer vertical-magnetic-recording medium which formed the soft-magnetism film on the substrate and formed perpendicular magnetic anisotropy films through the structure control layer on this as vertical-magnetic-recording medium. In the case of the former, the main factor of a medium noise is the magnetic domain of the unordered structure formed in the interior of a record bit, and a magnetization transition region. On the other hand, in the case of the latter two-layer vertical-magnetic-recording medium, in addition to the magnetic domain of the unordered structure formed in the interior of a record bit, and a

magnetization transition region, a medium noise is generated also by disorder of the magnetic-domain structure of a soft-magnetism film prepared in the lower layer of perpendicular magnetic anisotropy films.

[0006] Many meanses to improve the stability of the noise reduction and the record magnetization in a vertical magnetic recording are proposed. For example Digest of the Fourth Perpendicular Magnetic As described by Recording Conference'97 and Digest of the Fifth Perpendicular Magnetic Recording Conference 2000 Improvement in the crystal stacking tendency of the CoCr alloy magnetic film by introduction of the two-layer ground layer which consists of a CoCr alloy / Ti, The method of improving the square shape ratio of perpendicular magnetic anisotropy films is proposed by covering a Co/Pt (or Pd) multilayer magnetic film on an CoCrPt-O granular mold magnetic film, a Co/Pt (or Pd) multilayer magnetic film, a Te-Fe-Co amorphous magnetic film, or a CoCr alloy magnetic film. However, conventionally [these], by the medium, although improved [tend], especially by one side, the ***** medium noise of stability of the magnetization by the angle-of-elevation type ratio improves in a changes nature noise, and it has been the obstacle of high-density record.

[0007] Moreover, the noise generated from the magnetic domain formed in the soft-magnetism layer formed in the lower layer of perpendicular magnetic anisotropy films is also an important technical problem. As a method which controls the magnetic-domain structure of a soft-magnetism film, the method of forming the magnetization film within a direct side in contact with the lower layer of a soft-magnetism film is proposed like JP,11-191217,A "the manufacture method of a vertical-magnetic-recording medium." Although the effect that disorder of the magnetic-domain structure of the soft-magnetism film by the external magnetic field can fall to some extent is accepted according to this method, there is a problem acting as [the noise which disorder of the magnetic-domain structure of the magnetization film within a field was imprinted by the soft-magnetism film on this, consequently generated from a soft-magnetism film in the regenerative signal of perpendicular magnetic anisotropy films is contained, and] the obstacle of high-density record by forming the magnetization film within a direct side in contact with the lower layer of a soft-magnetism film.

[0008] As perpendicular magnetic anisotropy films, Co is made into a principal component and Co alloy thin film which added Cr, Ta, Pt, Rh, Pd, Ti, nickel, Nb, Hf, B, etc. to this is used. As a Co alloy which constitutes a magnetic thin film, the material of hcp structure is mainly used. Co alloy thin film has an easy axis in the c axis of this crystal, and the <00.1> direction, and carries out orientation of this easy axis perpendicularly. A magnetic thin film is formed by the vacuum deposition method or the sputtering method. In order to improve the track recording density and the reproduction output when carrying out magnetic recording, to decrease a reproduction noise and to improve a magnetic-recording property, while improving the perpendicular stacking tendency of the c axis of the above-mentioned Co alloy thin film, the diameter of crystal grain needs to be controlled and the remedy of forming the ground layer for structure control between a substrate and a magnetic film for this reason is performed from the former.

[0009]

[Problem(s) to be Solved by the Invention] In order overly to realize high-density magnetic recording by the vertical-magnetic-recording medium, especially the vertical-magnetic-recording medium which has a lining soft-magnetism layer, it is important to keep stable reduction and record magnetization of the noise contained in the regenerative signal other than improvement in track recording density, especially the medium noise resulting from the fine structure of a medium. this invention aims at canceling the fault of the conventional technology on the basis of such a problem recognition, having the outstanding low noise figure and the stability of record magnetization on it, and providing it with overly suitable vertical-magnetic-recording medium and magnetic storage for high-density magnetic recording.

[0010]

[Means for Solving the Problem] In the vertical-magnetic-recording medium equipped with the lining soft-magnetism layer, this invention persons found out the following things, as a result of considering in detail the factor which bars the stability of record magnetization, and the cause of a medium noise. That is, in order to fill simultaneously the stability of (1) record magnetization, and reduction of a medium noise, the magnetic interaction between the magnetic particles of the formation of an angle-of-elevation mold ratio of a vertical-magnetic-recording layer and a magnetic film should need to be controlled. (2) The soft-magnetism layer which contributes to a regenerative signal in a vertical-magnetic-recording medium should be a field with a thickness [directly under perpendicular magnetic anisotropy films] of 10-100nm. (3) The disclosure magnetic field distribution of a vertical-magnetic-recording medium front face when the magnetic-domain structure of a lining soft-magnetism layer front face carries out magnetic recording is influenced, and increase a medium noise. (4) The letter noise of a spike generated from a soft-magnetism film can be reduced by controlling the magnetic-domain structure of the soft-magnetism film of a field with a thickness [directly under perpendicular magnetic anisotropy films] of 10-100nm.

[0011] In this invention, the following means attains the above-mentioned purpose.

(1) Use the perpendicular magnetic anisotropy films which consist of a two-layer magnetic layer whose composition differs at least. It considers as the medium composition which formed the CoCrPt alloy magnetic layer of ultra-thin high

Pt concentration in either of one side of the CoCr alloy perpendicular magnetic anisotropy films of the high Cr concentration of the role which weakens the magnetic interaction between magnetic particles and specifically promotes detailed-ization of magnetic-domain size, and these perpendicular magnetic anisotropy films, or both sides. CoCr_xMy with Cr concentration high as former CoCr alloy perpendicular magnetic anisotropy films ($x = 18 - 22\text{at\%}$) Weaken the magnetic interaction between magnetic particles using M:Pt, one or more sorts of elements chosen from Ta, B, Nb, and Hf, and the hcp structure magnetic film which consists of $y = 14 - 3\text{at\%}$, and detailed-ization of magnetic-domain size is promoted. The coercive force and the magnetic anisotropy of a magnetic film are improved using the material of the hcp structure of the composition range of low Cr concentration (8 - 15at%) and high Pt concentration (15 - 25at%) as a latter CoCrPt alloy magnetic layer. The thickness of a CoCrPt alloy magnetic layer sets to 10nm or less, and may be 2-6nm desirably. Above-mentioned CoCr alloy perpendicular magnetic anisotropy films and an above-mentioned CoCrPt alloy magnetic layer make a substrate side carry out orientation of the c axis of an easy axis to a perpendicular mostly.

[0012] The former high Cr concentration CoCr alloy perpendicular magnetic anisotropy films are selecting Cr concentration in the range of 18 - 22at%, and carry out the operation which weakens the magnetic interaction between magnetic particles and promotes detailed-ization of magnetic-domain size. The CoCrPt alloy magnetic layer of the latter low Cr concentration and high Pt concentration is making Cr concentration into the range of 8 - 15at%, and making Pt concentration into the range of 15 - 25at%, there is an operation which improves the coercive force and the magnetic anisotropy of a magnetic film, and promotes the stability of magnetization, and in order to promote epitaxial growth of both magnetic films, it chooses the magnetic-film composition which all takes hcp structure.

[0013] (2) Prepare the layer chosen from Ru layer of the range of 0.5-1nm, a CoRuy ($x = 35 - 40\text{at\%}$) alloy layer, and a CoCr_xRuy ($x = 20 - 25\text{at\%}$, and $y = 25 - 20\text{at\%}$) alloy layer between the aforementioned CoCr alloy perpendicular magnetic anisotropy films and a CoCrPt alloy magnetic layer. The counter diffusion between CoCr alloy perpendicular magnetic anisotropy films and a CoCrPt alloy magnetic layer can be reduced by this, and it is effective in improvement in the magnetic anisotropy of perpendicular magnetic anisotropy films. In order that Ru layer, a CoRuy alloy layer, and a CoCr_xRuy alloy layer may maintain epitaxial growth between CoCr alloy perpendicular magnetic anisotropy films and a CoCrPt alloy magnetic layer, the composition range used as hcp structure is chosen, and the thickness carries out to the thickness which keeps the static magnetism-interaction between both magnetic films moderate, i.e., 0.5-1nm.

[0014] (3) Arrange an antiferromagnetism layer to the field (lower part which separated 10-100nm from the lowest side of perpendicular magnetic anisotropy films) to which the range of 10-100nm was chosen from the lowest side of perpendicular magnetic anisotropy films, and control the magnetic anisotropy of this antiferromagnetism layer and the soft-magnetism layer prepared between perpendicular magnetic anisotropy films. Let an antiferromagnetism layer be the material chosen from Mn-X (X:Ir, Pt, Fe) or a Cr-Mn-Pt alloy.

(4) Prepare a soft-magnetism layer in both sides of the antiferromagnetism layer arranged in the lower layer of perpendicular magnetic anisotropy films, form the flux return path of the disclosure magnetic field from a recording head in the case of magnetic recording, and improve record efficiency.

[0015] (5) Prepare the nonmagnetic interlayer of 1-5nm of thickness between perpendicular magnetic anisotropy films and a lining soft-magnetism layer. In addition to the crystal orientation of perpendicular magnetic anisotropy films and the diameter control of crystal grain which are formed on this, a nonmagnetic interlayer is effective in reducing the noise generated from a lining soft-magnetism layer by weakening the magnetic interaction between perpendicular magnetic anisotropy films and a lining soft-magnetism layer. As a nonmagnetic interlayer, the thin film of the shape of amorphous [, such as for example, a TiCr alloy, a CoCr alloy, a NiTaZr alloy, Ti, or Si, germanium C,] can be used.

[0016] As a lining soft-magnetism layer, which soft-magnetism layer of un-pillar-shaped polycrystal films, such as a Co-Zr-X (X:Ta, Nb, Mo, W, nickel) system amorphous alloy film or an Fe-aluminum-Si alloy, and a Fe-C-Y (Y:Ta, Hf, Zr, Nb) alloy, is used. By un-pillar-shaped polycrystal film-ization, the particle-size expansion by growth of a columnar grain is prevented, and reduction of the noise by detailed-izing of magnetic-domain size can be performed. In order to inhibit the letter noise of a spike by the formation of many magnetic domains of a lining soft-magnetism layer, the magnetic-domain fixed bed which consists of an antiferromagnetism layer or a magnetization film within a field through an ultra-thin NiFe layer or a CoFe layer in contact with the above-mentioned soft-magnetism layer is prepared, and single magnetic-domain-ization of the above-mentioned soft-magnetism layer is promoted.

[0017] Magnetic storage by this invention is characterized by using the above-mentioned vertical-magnetic-recording medium as a vertical-magnetic-recording medium in magnetic storage equipped with a magnetic-recording medium, the ring-type or single magnetic pole type head for magnetic recording, and a magnetoresistance-effect type, a spin bulb type or the magnetic tunnel type head for signal regeneration.

[0018]

[Embodiments of the Invention] The example of this invention is given to below, and it explains in detail, referring to a

drawing. In drawing, the portion which attached the same sign shows the portion which has the same function. [Example 1] Drawing 1 (a), (b), and (c) are the cross sections showing an example of the basic structure of the vertical-magnetic-recording medium by this invention. The vertical-magnetic-recording medium shown in drawing 1 forms the magnetic-domain fixed bed 12, the nonmagnetic interlayer 14, the perpendicular magnetic anisotropy films 18, and the protective layer 17 for magnetic-domain control of the lining soft-magnetism layer 13 one by one on a substrate 11, and is constituted. Perpendicular magnetic anisotropy films 18 consist of a magnetic film A15 which consists of CoCr_xMy alloy perpendicular magnetic anisotropy films ($y = 14 - 3\text{at\%}$ containing one or more sorts of elements chosen from M:Pt, and Ta, B, Nb and Hf $x = 18 - 22\text{at\%}$) of high Cr concentration, and a magnetic film B16 which consists of a CoCrPt alloy magnetic layer of the composition range of low Cr concentration (8 - 15at%) and high Pt concentration (15 - 25at%). The medium by which drawing 1 (a) formed the magnetic film B16 in the upper layer of a magnetic film A15, the medium by which drawing 1 (b) formed the magnetic film B16 in the lower layer of a magnetic film A15, and drawing 1 (c) show the composition of the medium which formed the magnetic film B16 in the vertical layer of a magnetic film A15.

[0019] By adding high-concentration Cr, a magnetic film A15 weakens the magnetic interaction between magnetic particles, promotes detailed-ization of magnetic-domain size, and by forming low Cr concentration and the magnetic film B16 which carried out high concentration Pt addition in one side or both sides of this magnetic film A15, where detailed-ization of magnetic-domain size is maintained, it improves the magnetic anisotropy of perpendicular magnetic anisotropy films 18. The thickness of a magnetic film B (CoCrPt alloy magnetic layer) sets to 10nm or less, and may be 2-6nm desirably.

[0020] The nonmagnetic interlayer 14 is formed between perpendicular magnetic anisotropy films 18 and the lining soft-magnetism layer 13. In addition to the crystal orientation of perpendicular magnetic anisotropy films and the diameter control of crystal grain which are formed on this, the nonmagnetic interlayer 14 is effective in reducing the noise generated from a lining soft-magnetism layer by weakening the magnetic interaction between perpendicular magnetic anisotropy films and a lining soft-magnetism layer. As a nonmagnetic interlayer, the thin film of the shape of amorphous [, such as for example, a TiCr alloy, a CoCr alloy, a NiTaZr alloy, Ti, or Si germanium, C,] etc. can be used. The nonmagnetic interlayer's 14 thickness may be 1-5nm.

[0021] The lining soft-magnetism layer 13 carries out the role of the improvement in a reproduction output by negating the role of the improvement in record efficiency, and the magnetic pole under perpendicular magnetic anisotropy films as a return path of the magnetic field generated from a recording head. When the width of recording track of a recording head is about 0.2 micrometers, as for the thickness of the lining soft-magnetism layer which acts as a return path for the improvement in record efficiency, 200-400nm is needed. In order to inhibit letter noise generating of a spike by the formation of many magnetic domains of the lining soft-magnetism layer 13, the magnetic-domain fixed bed 12 is formed, and the magnetic anisotropy of the lining soft-magnetism layer 13 is controlled in the specific direction of a magnetic disk (for example, radial). The magnetic-domain fixed bed 12 covers and constitutes antiferromagnetism films, such as a CrMnPr alloy, a MnPt alloy, a FeMn alloy, and an IrMn alloy, or a NiFe alloy film thin on the front face of this antiferromagnetism film and a CoFe alloy film. Moreover, the magnetic-domain fixed bed 12 can be constituted combining the CoCr alloy film which carried out orientation within a field or the CoCr alloy film which carried out orientation within a field, and the aforementioned antiferromagnetism film.

[0022] Drawing 2 (a), (b), and (c) are the cross sections showing other examples of the basic structure of the vertical-magnetic-recording medium by this invention. The vertical-magnetic-recording medium shown in drawing 2 forms the magnetic-domain fixed bed 12 for [of the lining soft-magnetism layer 13] carrying out magnetic-domain control, the nonmagnetic interlayer 14, perpendicular magnetic anisotropy films 18, and a protective layer 17 one by one on a substrate 11, and is constituted. The magnetic film A15 which perpendicular magnetic anisotropy films 18 turn into from the CoCr_xMy alloy perpendicular magnetic anisotropy films ($y = 14 - 3\text{at\%}$ containing one or more sorts of elements chosen from M:Pt, and Ta, B, Nb and Hf $x = 18 - 22\text{at\%}$) of high Cr concentration, The magnetic film B16 which consists of a CoCrPt alloy magnetic layer of the composition range of low Cr concentration (8 - 15at%) and high Pt concentration (15 - 25at%) is included. Between the magnetic film A15 and the magnetic film B16, which layer of Ru layer, a CoRu alloy layer, and a CoCrRu layer is prepared as a buffer layer 19. The medium by which drawing 2 (a) formed the magnetic film B16 in the upper layer of a magnetic film A15 through the buffer layer 19, the medium by which drawing 2 (b) formed the magnetic film B16 in the lower layer of a magnetic film A15 through the buffer layer 19, and drawing 2 (c) show the composition of the medium which formed the magnetic film B16 in the vertical layer of a magnetic film A15 through the buffer layer 19.

[0023] By adding high-concentration Cr, a magnetic film A15 weakens the magnetic interaction between magnetic particles, promotes detailed-ization of magnetic-domain size, and by forming low Cr concentration and the magnetic film B16 which carried out high concentration Pt addition in one side or both sides of this magnetic film A15, where

detailed-ization of magnetic-domain size is maintained, it improves the magnetic anisotropy of perpendicular magnetic anisotropy films 18. The thickness of a magnetic film B16 (CoCrPt alloy magnetic layer) sets to 10nm or less, and may be 2-6nm desirably. A buffer layer 19 controls the counter diffusion between a magnetic film A15 and a magnetic film B16, and raises the magnetic anisotropy of perpendicular magnetic anisotropy films by static magnetism-combination between both magnetic-films films. The thickness of a buffer layer 19 may be 0.5-1nm.

[0024] The nonmagnetic interlayer 14 is formed between perpendicular magnetic anisotropy films 18 and the lining soft-magnetism layer 13. In addition to the crystal orientation of perpendicular magnetic anisotropy films and the diameter control of crystal grain which are formed on this, the nonmagnetic interlayer 14 is effective in reducing the noise generated from a lining soft-magnetism layer by weakening the magnetic interaction between perpendicular magnetic anisotropy films and a lining soft-magnetism layer. As a nonmagnetic interlayer, the thin film of the shape of amorphous [, such as for example, a TiCr alloy, a CoCr alloy, a NiTaZr alloy, Ti, or Si germanium, C] can be used. The nonmagnetic interlayer's 14 thickness may be 1-5nm.

[0025] The lining soft-magnetism layer 13 carries out the role of the improvement in a reproduction output by negating the role of the improvement in record efficiency, and the magnetic pole under perpendicular magnetic anisotropy films as a return path of the magnetic field generated from a recording head. In order to inhibit generating of the letter noise of a spike by the formation of many magnetic domains of the lining soft-magnetism layer 13, the magnetic-domain fixed bed 12 is formed, and the magnetic anisotropy of the lining soft-magnetism layer 13 is controlled in the specific direction of a magnetic disk (for example, radial). The magnetic-domain fixed bed 12 covers and constitutes antiferromagnetism films, such as a CrMnPr alloy, a MnPt alloy, a FeMn alloy, and an IrMn alloy, or a NiFe alloy film thin on the front face of this antiferromagnetism film and a CoFe alloy film. Moreover, the magnetic-domain fixed bed 12 can be constituted combining the CoCr alloy film which carried out orientation within a field or the CoCr alloy film which carried out orientation within a field, and the aforementioned antiferromagnetism film.

[0026] Drawing 3 explains one example of the magnetic storage used for evaluation of the record reproducing characteristics of the medium by this invention. Magnetic storage consists of the suspension 33 which supports a magnetic disk 31, the magnetic head 32 for record reproduction, and the magnetic head, an actuator 34, a voice coil motor 35, a record regenerative circuit 36, a positioning circuit 37, an interface-control circuit 38, etc. A magnetic disk 31 consists of a vertical-magnetic-recording medium explained by drawing 1 and drawing 2, and lubricating film is covered on the protective coat. The magnetic head 32 consists of heads for reproduction which consist of a slider, the head for magnetic recording prepared on this and the magnetoresistance-effect type for signal regeneration, a huge magnetoresistance-effect type, a spin bulb type element, or a magnetic tunnel type element. The gap length of the magnetic head for record signal regeneration sets to 0.25 micrometers or less, in order to obtain the regenerative signal of a high resolution, and it may be 0.08-0.15 micrometers desirably. The single magnetic pole type head was used for the head for magnetic recording. The width of recording track of the head for reproduction is made narrower than the width of recording track of the head magnetic pole for record, and reduces the reproduction noise produced from recording track both ends. The magnetic head 2 is supported by the suspension 3. The medium noise figure of this example and record reproducing-characteristics evaluation were performed using this equipment.

[0027] The detail of the vertical-magnetic-recording medium shown in drawing 1 (a), (b), and (c) is explained below. By the high-vacuum DC magnetron sputtering system, medium 1A which shows cross-section structure to drawing 1 (a) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film A15 which besides consists of the Co-22at%Cr-14at%Pt alloy of 15nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness, and a magnetic film B16 which consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0028] By the high-vacuum DC magnetron sputtering system, medium 1B which shows cross-section structure to drawing 1 (b) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular

magnetic anisotropy films 18 which consist of a magnetic film B16 which besides consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness, and a magnetic film A15 which consists of the Co-22at%Cr-14at%Pt alloy of 15nm of thickness were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18. [0029] By the high-vacuum DC magnetron sputtering system, medium 1C which shows cross-section structure to drawing 1 (c) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film B16 which besides consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness, a magnetic film A15 which consists of the Co-22at%Cr-14at%Pt alloy of 10nm of thickness, and a magnetic film B16 which consists of the Co-8at%Cr-20at%Pt alloy of 5 The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0030] The detail of the vertical-magnetic-recording medium shown in drawing 2 (a), (b), and (c) is explained below. By the high-vacuum DC magnetron sputtering system, medium 2A which shows cross-section structure to drawing 2 (a) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film A15 which besides consists of the Co-22at%Cr-14at%Pt alloy of 15nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness, a buffer layer 19 which consists of an Ru layer of 0.8nm of thickness, and a magnetic film B16 which consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0031] By the high-vacuum DC magnetron sputtering system, medium 2B which shows cross-section structure to drawing 2 (b) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film B16 which besides consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness, a buffer layer 19 which consists of an Ru layer of 0.8nm of thickness, and a magnetic film A15 which consists of the Co-22at%Cr-14at%Pt alloy of 15nm of thickness were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0032] By the high-vacuum DC magnetron sputtering system, medium 2C which shows cross-section structure to drawing 2 (c) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The nonmagnetic interlayer 14 who besides consists of Ti-10at%Cr of 5nm of thickness is minded. The magnetic film B16 which consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness, The buffer layer 19 which consists of an Ru layer of 0.8nm of thickness, It forms in order of the magnetic film A15 which consists of the Co-22at%Cr-14at%Pt alloy of 10nm of thickness, the buffer layer 19 which consists of an Ru layer of 0.8nm of thickness, and the magnetic film B16 which consists of the Co-8at%Cr-20at%Pt alloy of 5nm of thickness. The perpendicular magnetic anisotropy films 18 constituted were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0033] The medium R1 for comparison was produced by the high-vacuum DC magnetron sputtering system. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film A15 which besides consists of the Co-22at%Cr-14at%Pt alloy of 20nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness were formed. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0034] The medium R2 for comparison was produced by the high-vacuum DC magnetron sputtering system. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%nickel-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which consist of a magnetic film B16 which besides consists of the Co-8at%Cr-20at%Pt alloy of 20nm of thickness through the nonmagnetic interlayer 14 who consists of Ti-10at%Cr of 5nm of thickness were produced. The C protective layer 17 of 5nm of thickness was formed in the front face of perpendicular magnetic anisotropy films 18.

[0035] The c axis of hcp structure is carrying out orientation of each perpendicular magnetic anisotropy films of the media 1A, 1B, 1C, and 2A produced by this example, 2B, 2C, and the media R1 and R2 for comparison to the perpendicular mostly in the substrate side, and growing up in epitaxial was checked by transmission-electron-microscope observation of an X-ray diffraction method and a thin film cross section. In this example, although an example of material, such as the magnetic-domain fixed bed, a nonmagnetic interlayer, perpendicular magnetic anisotropy films, and a buffer layer, explained the content of this invention, in addition even if it uses the combination of said material composition, it is possible to acquire the same effect.

[0036] The property of the media 1A, 1B, 1C, and 2A of the above-mentioned this invention, 2B, 2C, and the media R1 and R2 for comparison is shown as compared with Table 1. In a table, the coercive force (Hc) of a medium and a square shape ratio (Mr/Ms) are the magnetic properties of the film surface perpendicularly it measured with the Kerr effect type magnetometer. the magnetic ***** above-mentioned medium which sketched in drawing 3 -- the single magnetic pole type magnetic head of 0.2m of width of recording track -- magnetic recording -- carrying out -- a huge magnetic-reluctance type head (GMR head) with a shield interval of 80nm -- reproducing -- a medium noise and record -- resolution was measured The spacing at the time of record reproduction was set to 16nm. The magnetic-domain structure on the front face of a medium which carried out AC erasion was observed under the magnetic-force microscope, and the size of the irregular magnetic domain formed in the front face was measured. The diameter when resembling the circle of the same area compared the size of an irregular magnetic domain here. so that the path of an irregular magnetic domain is large -- a medium noise -- large -- record -- there is a property in which resolution falls The magnetization attenuation factor recorded the magnetic signal of the recording density range of 400kFCI(s) (Kilo Flux Change per Inch) from low track recording density, and measured the rate of the signal strength after fixed time progress to the signal immediately after record. The magnetization attenuation factor 1 hour after the record signal of track-recording-density 100kFCI is shown in Table 1.

[0037]

[Table 1]

媒体	磁区固定層 下層/MnIr/NiFe	垂直軟磁性層 CoTaZr	垂直磁化率		H_c (Oe)	Mr/Ms	ノイズ (mVrms/mVpp)	分解能 (kFCI)	不規則磁区径 (nm)	磁化減衰率 (%)
			下層磁性膜/上層磁性膜							
1A	NiFe/MnIr/NiFe	CoTaZr	磁性膜A(15)/磁性膜B(5)		3480	1	0.085	350	67	<1
1B	NiFe/MnIr/NiFe	CoTaZr	磁性膜B(5)/磁性膜A(15)		3410	1	0.084	345	69	1
1C	NiFe/MnIr/NiFe	CoTaZr	磁性膜B(5)/磁性膜A(10)/磁性膜B(5)		3380	1	0.013	325	75	2
2A	NiFe/MnIr/NiFe	CoTaZr	磁性膜A(15)/Ru(0.6)/磁性膜B(5)		3620	1	0.006	360	65	<1
2B	NiFe/MnIr/NiFe	CoTaZr	磁性膜B(5)/Ru(0.6)/磁性膜A(15)		3640	1	0.009	354	68	<1
2C	NiFe/MnIr/NiFe	CoTaZr	磁性膜B(5)/Ru(0.6)/磁性膜A(10)/Ru(0.6)/磁性膜B(5)		3480	1	0.011	330	72	1
R1	NiFe/MnIr/NiFe	CoTaZr	磁性膜A(20)		2850	0.91	0.02	290	95	12
R2	NiFe/MnIr/NiFe	CoTaZr	磁性膜B(20)		3050	1	0.04	120	150	5

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磁性膜Aは、Co-22at%Cr-14at%Pt合金磁性膜、磁性膜BはCo-8at%Cr-20at%Pt合金磁性膜である。

()内の数字は膜厚(nm)を示す。

ノイズは、総記録密度200 kFCIの出力で規格化した値で示す。(kFCI : kilo Flux Change per Inch)

分解能は伝導記録密度の出力の50%になる時の記録保密度で示す。

不規則磁区径は、交渉用法した試料表面の粗さ構造を磁気力顯微鏡で撮影し、同面積の円に近似したときの平均径を示す。

磁化減衰率は、総記録密度100 kFCIを記録し、記録直後の信号出力に対する1時間後の出力の割合で示す。

[0038] the former which consists of a monolayer of the CoCr alloy perpendicular magnetic anisotropy films of high Cr concentration so that clearly from comparison of Table 1 -- the medium R1 for comparison of medium composition -- reduction of a medium noise, and record -- resolution, although it is improvable to some extent with adoption of the CoCr alloy perpendicular magnetic anisotropy films of high Cr concentration, and an improvement of a ground layer one side -- the fall of a magnetic anisotropy -- a square shape ratio (Mr/Ms) -- falling -- the stability (magnetization attenuation factor) of magnetization -- deteriorating -- reduction of the above-mentioned medium noise, and record -- it is difficult to realize improvement in resolution, and stability of magnetization simultaneously although the magnetic anisotropy of the medium R2 of medium composition for comparison improves by the CoCrPt alloy magnetic layer of high Pt concentration, a square shape ratio (Mr/Ms) is large and the stability (magnetization attenuation factor) of magnetization improves conventionally -- a medium noise and record -- resolution is not good

[0039] By preparing the CoCrPt alloy magnetic layer of low Cr concentration (8 - 15at%) thin in the upper layer, lower layer, or vertical layer of CoCr alloy perpendicular magnetic anisotropy films of the above-mentioned quantity Cr concentration like this invention, and high Pt concentration (15 - 25at%) Compared with a medium, magnetic properties, such as coercive force (H_c) and a square shape ratio (Mr/Ms), have been improved sharply conventionally, and the extensive improvement of reduction of a medium noise, a record resolution enhancement, the stability of magnetization,

etc. became realizable simultaneously. Moreover, realization of high coercive force and an angle-of-elevation type ratio showed that the stability of 10% or less of magnetization was maintainable in the extensive recording density field of track-recording-density 5kFCI to 400kFCI(s).

[0040] [Example 2] The medium of this invention which shows cross-section structure to the medium and drawing 2 (a) of this invention which shows cross-section structure to drawing 1 (a) was taken for the example, and the magnetic-film thick dependency of a magnetic film A15 (CoCr alloy perpendicular magnetic anisotropy films of high Cr concentration) and a magnetic film B16 (CoCrPt alloy magnetic layer of low Cr concentration and high PtCr concentration) was investigated. Here, all thickness of the perpendicular magnetic anisotropy films which consist of a magnetic film A15 and a magnetic film B16 was set to 20nm, and the thickness of a magnetic film B16 was changed in 0-10nm.

[0041] By the high-vacuum DC magnetron sputtering system, the medium which shows cross-section structure to drawing 1 (a) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%Co-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-8at%Ta-5at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which besides consist of a magnetic film A15 and a magnetic film B16 through the nonmagnetic interlayer 14 who consists of nickel-5at%Ta-20at%Zr of 5nm of thickness were formed. Thickness was changed, respectively with 20nm, 19nm, 18nm, 16nm, 14nm, 12nm, and 10nm, using a Co-19at%Cr-12at%Pt-3at%B alloy as a magnetic film A15. Thickness was changed, respectively with 0nm, 1nm, 2nm, 4nm, 6nm, 8nm, and 10nm, using a Co-8at%Cr-22at%Pt alloy as a magnetic film B16. The medium in which the C protective layer 17 of 5nm of thickness was formed on the front face of perpendicular magnetic anisotropy films 18 was produced.

[0042] By the high-vacuum DC magnetron sputtering system, the medium which shows cross-section structure to drawing 2 (a) was produced. The washed glass substrate 11 was installed in the sputtering system, Ta precoat layer of 5nm of thickness, the 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film of 50nm of thickness, and the 80at%Co-Fe film of 5nm of thickness were formed one by one, were heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 was formed. The lining soft-magnetism layer 13 which consists of Co-8at%Ta-5at%Zr of the amorphous structure of 200nm of thickness was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The perpendicular magnetic anisotropy films 18 which besides formed the magnetic film A15, the buffer layer 19, and the magnetic film B16 one by one through the nonmagnetic interlayer 14 who consists of nickel-5at%Ta-20at%Zr of 5nm of thickness were produced. The Co-40at%Ru alloy of 0.8nm of thickness was used as a buffer layer 19. Thickness was changed, respectively with 20nm, 19nm, 18nm, 16nm, 14nm, 12nm, and 10nm, using a Co-19at%Cr-12at%Pt-3at%B alloy as a magnetic film A15. Thickness was changed, respectively with 0nm, 1nm, 2nm, 4nm, 6nm, 8nm, and 10nm, using a Co-8at%Cr-22at%Pt alloy as a magnetic film B16. The medium in which the C protective layer 17 of 5nm of thickness was formed on the front face of perpendicular magnetic anisotropy films 18 was produced.

[0043] The c axis of hcp structure is carrying out orientation of each perpendicular magnetic anisotropy films produced by this example to the perpendicular mostly in the substrate side, and growing up in epitaxial was checked by transmission-electron-microscope observation of an X-ray diffraction method and a thin film cross section. In this example, although an example of material, such as the magnetic-domain fixed bed, a nonmagnetic interlayer, perpendicular magnetic anisotropy films, and a buffer layer, explained the content of this invention, in addition even if it uses the combination of said material composition, it is possible to acquire the same effect.

[0044] The property of the above-mentioned medium is compared and shown in Table 2. In a table, the coercive force (Hc) of a medium and a square shape ratio (Mr/Ms) are the magnetic properties of the film surface perpendicularly it measured with the Kerr effect type magnetometer. the magnetic ***** above-mentioned medium which sketched in drawing 3 -- the single magnetic pole type magnetic head of 0.2m of width of recording track -- magnetic recording -- carrying out -- a huge magnetic-reluctance type head (GMR head) with a shield interval of 80nm -- reproducing -- a medium noise and record -- resolution was measured The spacing at the time of record reproduction was set to 16nm. The magnetic-domain structure on the front face of a medium which carried out AC erasion was observed under the magnetic-force microscope, and the size of the irregular magnetic domain formed in the front face was measured. The diameter when resembling the circle of the same area compared the size of an irregular magnetic domain here.

[0045]

[Table 2]

媒体	磁区固定層	裏打軟磁性層	垂直磁化膜	Hc (Oe)	Mr/Ms	ノイズ (mVrms/mVpp)	分解能 (kFCI)	不規則磁区径 (nm)
			下層磁性膜/上層磁性膜					
1A1	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(20)/磁性膜B(0)	2900	0.88	0.018	280	85
1A2	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(18)/磁性膜B(1)	3100	0.91	0.016	300	78
1A3	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(18)/磁性膜B(2)	3320	0.98	0.011	340	75
1A4	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(16)/磁性膜B(4)	3580	1	0.008	360	65
1A5	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(14)/磁性膜B(6)	3840	1	0.009	354	68
1A6	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(12)/磁性膜B(8)	3720	1	0.017	302	79
1A7	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(10)/磁性膜B(10)	3800	1	0.025	275	102
2A1	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(20)/バッファー層(0)/磁性膜B(0)	2920	0.87	0.018	285	86
2A2	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(18)/バッファー層(0.8)/磁性膜B(1)	3120	0.94	0.017	298	79
2A3	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(18)/バッファー層(0.8)/磁性膜B(2)	3340	0.99	0.011	342	74
2A4	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(16)/バッファー層(0.8)/磁性膜B(4)	3592	1	0.0078	364	63
2A5	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(14)/バッファー層(0.8)/磁性膜B(6)	3845	1	0.0087	355	87
2A6	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(12)/バッファー層(0.8)/磁性膜B(8)	3730	1	0.016	305	77
2A7	NiFe/MnIr/CoFe	CoTaZr	磁性膜A(10)/バッファー層(0.8)/磁性膜B(10)	3820	1	0.026	272	100

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磁性膜Aは、Co-19at%Cr-12at%Pt-3at%B合金磁性膜、磁性膜Bは、Co-8at%Cr-22at%Pt合金磁性膜である。

()内の数字は膜厚(nm)を示す。

[0046] It compares with the conventional medium which consists of a Co-19at%Cr-12at%Pt-3at%B alloy magnetic-film (magnetic film A) monolayer which is the CoCr alloy perpendicular magnetic anisotropy films of high Cr concentration so that clearly from comparison of Table 2. By forming the magnetic film B which becomes the upper layer of a magnetic film A from the CoCrPt alloy magnetic layer of low Cr concentration and high PtCr concentration like this invention Magnetic properties, such as coercive force and a square shape ratio, can be improved sharply, the stability (magnetization attenuation factor) of 10% or less of magnetization can be secured in the large range of track-recording-density 5kFCI to 400kFCI(s) by realization of high coercive force and an angle-of-elevation type ratio, and reduction and the record resolution enhancement of a medium noise can be realized simultaneously. The desirable thickness of the magnetic film B which consists of a CoCrPt alloy magnetic layer of low Cr concentration and high PtCr concentration formed in the upper layer of a magnetic film A is 2-6nm.
 [0047] In this example, in the perpendicular magnetic anisotropy films of the composition of drawing 1 (a) which formed the magnetic film B through direct or the buffer layer on the magnetic film A, and drawing 2 (a), although this invention was explained to the example, the effect with the same said of the perpendicular magnetic anisotropy films of the composition of drawing 1 (b), (c), and drawing 2 (b) and (c) was acquired.

[0048] [Example 3] When the material composition of the magnetic-domain fixed bed 12 is changed, drawing 4 explains an example which compared the letter noise of a spike generated from the lining soft-magnetism layer 13. The magnetic-domain fixed bed 12 and the lining soft-magnetism layer 13 are formed on a substrate 11. The nonmagnetic interlayer 14 who besides consists of nickel-5at%Ta-20at%Zr of 5nm of thickness, the magnetic film A15 which consists of the Co-19at%Cr-12at%Pt-3at%B alloy of 15nm of thickness, the magnetic film B16 which consists of the Co-8at%Cr-22at%Pt alloy of 5nm of thickness, And the content is explained using the sample of the composition of drawing 1 (a) which formed the C protective layer 17 of 5nm of thickness one by one. as the lining soft-magnetism layer 13 -- Co-10at%Ta-2at% -- Zr amorphous film, the Fe-8at%Ta-12at%C polycrystal film, and the Fe-12at%aluminum-5at%Si polycrystal film were used

[0049] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one, was heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 of the composition The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The anisotropy was given to radial [of a magnetic disk] by this processing. The media D1, D2, and D3 which formed the lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of amorphous structure (100nm of thickness, 200nm, and 300nm) on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and formed the aforementioned

nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this successively were produced. The medium D4 which did not form the magnetic-domain fixed bed 12 for comparison, but formed the lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of 300nm of direct thickness on the glass substrate 11, and formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this was produced.

[0050] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, and Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one. The magnetic-domain fixed bed 12 of the composition of drawing 4 (b) which formed in order the magnetization film A26 within a field which besides consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness, the Ru film 27 of 0.8nm of thickness, and the magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was produced. The magnetic-domain fixed bed 12 was heat-treated among 300 degrees C and the magnetic field of 2kOe. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The anisotropy was given to radial [of a magnetic disk] by this processing. A Co-18at%Cr-14at%Pt magnetic film has a magnetic anisotropy in film surface inboard, carried out ferromagnetic combination with the lower layer NiFe film, and the anisotropy was given to radial [of a magnetic disk]. The media E1, E2, and E3 which formed the lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of amorphous structure (100nm of thickness, 200nm, and 300nm) on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this successively were produced.

[0051] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system is installed. The NiAlTa precoat layer 22 of 20nm of thickness, the Cr-10at%Ti ground layer 29 of 5nm of thickness, the magnetization film A26 within a field that consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness on this, the Ru film 27 of 0.8nm of thickness, The magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was formed in order. Then, the magnetic-domain fixed bed 12 of the composition of drawing 4 (c) which formed the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness one by one was produced. The magnetic-domain fixed bed 12 was heat-treated among 300 degrees C and the magnetic field of 2kOe. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The anisotropy was given to radial [of a magnetic disk] by this processing. A Co-18at%Cr-14at%Pt magnetic film has a magnetic anisotropy in film surface inboard, carried out ferromagnetic combination with the upper NiFe film, and the anisotropy was given to radial [of a magnetic disk]. The media F1, F2, and F3 which formed the lining soft-magnetism layer 13 which consists of Co-10at%Ta-2at%Zr of amorphous structure (100nm of thickness, 200nm, and 300nm) on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this successively were produced.

[0052] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one, and the magnetic-domain fixed bed 12 of the composition of drawing 4 (a) was formed. The lining soft-magnetism layer 13 which consists of a Fe-8at%Ta-12at%C polycrystal film (100nm of thickness, 200nm, and 300nm) was successively formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and 400 degrees C and heat treatment of 1kOe among a magnetic field were carried out. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The Fe-8at%Ta-12at%C film was constituted from a microcrystal grain of Fe with a particle size of about 10nm by this processing. The media G1 and G2 and G3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced. The medium G4 which did not form the magnetic-domain fixed bed 12 for comparison, but formed the lining soft-magnetism layer 13 which consists of Fe-8at%Ta-12at%C of 300nm of direct thickness on the glass substrate 11, and formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this was produced.

[0053] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, and Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one. The magnetic-domain fixed bed 12 of the composition of drawing 4 (b) which formed in order the magnetization film A26 within a field which besides consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness, the Ru film 27 of 0.8nm of thickness, and the magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was produced. The lining soft-magnetism layer 13 which consists of a Fe-8at%Ta-12at%C polycrystal film (100nm of thickness, 200nm, and 300nm) was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and 400 degrees C and heat treatment of 2kOe among a magnetic field were carried out. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The Fe-8at%Ta-12at%C film was constituted from a microcrystal grain of Fe with a particle size of about 10nm by this processing. The media H1, H2, and H3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced.

[0054] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system is installed. The NiAlTa precoat layer 22 of 20nm of thickness, the Cr-10at%Ti ground layer 29 of 5nm of thickness, the magnetization film A26 within a field that consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness on this, the Ru film 27 of 0.8nm of thickness, The magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was formed in order. Then, the magnetic-domain fixed bed 12 of the composition of drawing 4 (c) which formed the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness one by one was produced. The lining soft-magnetism layer 13 which consists of a Fe-8at%Ta-12at%C polycrystal film (100nm of thickness, 200nm, and 300nm) was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and 400 degrees C and heat treatment of 2kOe among a magnetic field were carried out. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The Fe-8at%Ta-12at%C film was constituted from a microcrystal grain of Fe with a particle size of about 10nm by this processing. The media J1, J2, and J3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced.

[0055] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one, and the magnetic-domain fixed bed 12 of the composition of drawing 4 (a) was formed. The lining soft-magnetism layer 13 which consists of a Fe-12at%aluminum-5at%Si polycrystal film (100nm of thickness, 200nm, and 300nm) was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum, and 300 degrees C and heat treatment of 1kOe among a magnetic field were carried out. The Fe-12at%aluminum-5at%Si lining soft-magnetism layer 13 was made into the laminated structure of the Fe-12at%aluminum-5at%Si layer and Si layer of 1nm of thickness of 20nm of thickness in order to prevent big and rough-ization of the grain by thin film formation inside column-like crystal growth. The lining soft-magnetism layer 13 which consists of a Fe-12at%aluminum-5at%Si polycrystal film by this became a fine crystal grain with a particle size of 20nm or less. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The media K1, K2, and K3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced. The medium K4 which did not form the magnetic-domain fixed bed 12 for comparison, but formed the lining soft-magnetism layer 13 which consists of a Fe-12at%aluminum-5at%Si polycrystal film of 300nm of direct thickness on the glass substrate 11, and formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on this was produced. The Fe-12at%aluminum-5at%Si lining soft-magnetism layer 13 was made into the laminated structure of the Fe-12at%aluminum-5at%Si layer and Si layer of 1nm of thickness of 20nm of thickness in order to prevent big and rough-ization of the grain by thin film formation inside column-like crystal growth.

[0056] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, and Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of

thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one. The magnetic-domain fixed bed 12 of the composition of drawing 4 (b) which formed in order the magnetization film A26 within a field which besides consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness, the Ru film 27 of 0.8nm of thickness, and the magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was produced. The lining soft-magnetism layer 13 which consists of a Fe-12at%aluminum-5at%Si polycrystal film (100nm of thickness, 200nm, and 300nm) was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The Fe-12at%aluminum-5at%Si lining soft-magnetism layer 13 was made into the laminated structure of the Fe-12at%aluminum-5at%Si layer and Si layer of 1nm of thickness of 20nm of thickness in order to prevent big and rough-ization of the grain by thin film formation inside column-like crystal growth. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The media L1, L2, and L3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced.

[0057] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system is installed. The NiAlTa precoat layer 22 of 20nm of thickness, the Cr-10at%Ti ground layer 29 of 5nm of thickness, the magnetization film A26 within a field that consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness on this, the Ru film 27 of 0.8nm of thickness, The magnetization film B28 within a field which consists of a Co-18at%Cr-14at%Pt magnetic film of 10nm of thickness was formed in order. Then, the magnetic-domain fixed bed 12 of the composition of drawing 4 (c) which formed the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 80at%Mn-Ir antiferromagnetism film 24 of 50nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness one by one was produced. The lining soft-magnetism layer 13 which consists of a Fe-12at%aluminum-5at%Si polycrystal film (100nm of thickness, 200nm, and 300nm) was successingly formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The Fe-12at%aluminum-5at%Si lining soft-magnetism layer 13 was made into the laminated structure of the Fe-12at%aluminum-5at%Si layer and Si layer of 1nm of thickness of 20nm of thickness in order to prevent big and rough-ization of the grain by thin film formation inside column-like crystal growth. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The media M1, M2, and M3 which formed the aforementioned nonmagnetic interlayer 14, the magnetic film A15, the magnetic film B16, and the protective layer 17 one by one on the lining soft-magnetism layer 13 were produced.

[0058] The medium D (-1, -2, -3, -4) produced by this example, Medium E (-1, -2, -3) Medium F (-1, -2, -3), Medium G (-1, -2, -3, -4) Medium H (-1, -2, -3), Medium J (-1, -2, -3), Medium K (-1, -2, -3, -4) Medium L (-1, -2, -3) and Medium M (-1, -2, -3) were installed in the magnetic recording medium which sketched in drawing 3 , and measurement comparison of the noise signal of the letter of a spike generated from the magnetic domain formed in the lining soft-magnetism layer 13 was carried out. The noise signal of the letter of a spike was defined as follows here. The direct current erase of the perpendicular magnetic anisotropy films 18 was carried out by the magnetic head, the signal of the shape of irregularity which has the signal strength of 1.2 times or more of the direct-current-erase noise level of the average detected by the reproducing head was made into the noise signal of the letter of a spike, and the number detected by per magnetic-disk round was compared. An example of a measurement result is shown as compared with Table 3.

[0059]

[Table 3]

媒体	磁区固定層	裏打軟磁性層	裏直磁化膜	スパイク信号数
D-1	NiFe/MnIr/NiFe	Co-10at%Ta-2at%Zr(100nm)	磁性膜A/磁性膜B	4
D-2	同上	同上(200nm)	同上	8
D-3	同上	同上(300nm)	同上	14
D-4	なし	同上(300nm)	同上	28
E-1	NiFe/MnIr/NiFe/CoCrPt/Ru/CoCrPt	Co-10at%Ta-2at%Zr(100nm)	同上	4
E-2	同上	同上(200nm)	同上	4
E-3	同上	同上(300nm)	同上	6
F-1	CoCrPt/Ru/CoCrPt/NiFe/MnIr/NiFe	Co-10at%Ta-2at%Zr(100nm)	同上	4
F-2	同上	同上(200nm)	同上	5
F-3	同上	同上(300nm)	同上	8
G-1	NiFe/MnIr/NiFe	Fe-8at%Ta-12at%C(100nm)	同上	10
G-2	同上	同上(200nm)	同上	11
G-3	同上	同上(300nm)	同上	12
G-4	なし	同上(300nm)	同上	16
H-1	NiFe/MnIr/NiFe/CoCrPt/Ru/CoCrPt	Fe-8at%Ta-12at%C(100nm)	同上	2
H-2	同上	同上(200nm)	同上	3
H-3	同上	同上(300nm)	同上	4
J-1	CoCrPt/Ru/CoCrPt/NiFe/MnIr/NiFe	Fe-8at%Ta-12at%C(100nm)	同上	7
J-2	同上	同上(200nm)	同上	10
J-3	同上	同上(300nm)	同上	12
K-1	NiFe/MnIr/NiFe	Fe-12at%Al-5at%Si (100nm)	同上	15
K-2	同上	同上(200nm)	同上	18
K-3	同上	同上(300nm)	同上	21
K-4	なし	同上(300nm)	同上	29
L-1	NiFe/MnIr/NiFe/CoCrPt/Ru/CoCrPt	Fe-12at%Al-5at%Si (100nm)	同上	5
L-2	同上	同上(200nm)	同上	6
L-3	同上	同上(300nm)	同上	8
M-1	CoCrPt/Ru/CoCrPt/NiFe/MnIr/NiFe	Fe-12at%Al-5at%Si (100nm)	同上	8
M-2	同上	同上(200nm)	同上	10
M-3	同上	同上(300nm)	同上	12

磁性膜A: Co-10at%Cr-12at%Pt-3at%B, 膜厚 15 nm

磁性膜B: Co-8at%Cr-22at%Pt, 膜厚 5 nm

[0060] By combining with the magnetic-domain fixed bed also in which lining soft-magnetism layer, formation of the magnetic domain to a lining soft-magnetism layer can be suppressed, and, as a result, the number of the letter noise signals of a spike can be sharply reduced so that clearly from comparison of Table 3. Moreover, by changing the composition of the magnetic-domain fixed bed, the strength of the ferromagnetic combination between the magnetic-domain fixed bed and a lining soft-magnetism layer can be controlled, the effect of magnetic-domain structure control can be demonstrated also to a thicker lining soft-magnetism layer, and the number of the letter noise signals of a spike can be reduced.

[0061] this example -- as a lining soft-magnetism layer -- Co-10at%Ta-2at%, although the example using Zr amorphous film, the Fe-8at%Ta-12at%C polycrystal film, and the Fe-12at%aluminum-5at%Si polycrystal film explained In addition, the same effect can be acquired even if it uses un-pillar-shaped polycrystal films, such as a Co-Zr-X (X:Ta, Nb, Mo, W, nickel) system amorphous alloy film or an Fe-aluminum-Si alloy, and a Fe-C-Y (Y:Ta, Hf, Zr, Nb) alloy. Moreover, although the example using the Mn-Ir alloy as an antiferromagnetism layer explained, you may use a Mn-Fe alloy, a Mn-Pt alloy, a Cr-Mn-Pt alloy, etc. for others. Furthermore, although the composition of drawing 1 (a) explained the content of invention as a vertical-magnetic-recording medium of this invention, an effect with the same said of the vertical-magnetic-recording medium composition of drawing 1 (b) of this invention, (c), drawing 2 (a), (b), and (c) can be acquired.

[0062] Although the example using the glass substrate as a substrate 11 explained, you may use Si disk substrate, a NiP covering aluminum substrate, a carbon substrate, or a macromolecule substrate other than a glass substrate. The sample which changed various composition of the magnetic film B16 of low Cr concentration and high Pt concentration used in the example 1, the example 2, and the example 3 was produced. the sample of the medium composition which showed drawing 5 to drawing 1, drawing 2, and drawing 4 -- setting -- reduction of a medium noise, and record -- O mark showed composition of the magnetic film B16 excellent in improvement in resolution, the stability of magnetization, and the low spike-noise property moreover, the field enclosed with the curve in drawing 5 -- the same -- reduction of a medium noise, and record -- they are improvement in resolution, the stability of magnetization, and the composition

range of the magnetic film B16 excellent in the low spike-noise property x mark shows composition with which the above-mentioned inadequate effect.

[0063] [Example 4] The arrangement place of an antiferromagnetism layer and the relation of a spike noise which were prepared in the lower layer of perpendicular magnetic anisotropy films for magnetic-domain fixation of a lining soft-magnetism layer were investigated. Although the effect that any medium composition of drawing 1 (a), (b), (c) or drawing 2 (a), (b), and (c) is the same is acquired, drawing 6 is used and this example explains the sample of the perpendicular medium composition of drawing 1 (a) for the contents to an example.

[0064] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, Ta precoat layer 22 of 5nm of thickness, the soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 48at%Mn-Ir antiferromagnetism film 24 of 20nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one, was heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 of the composition The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The anisotropy was given to radial [of a magnetic disk] by this processing. The lining soft-magnetism layer A41 which consists of Co-10at%Ta-2at%Zr of amorphous structure (10nm of thickness, 50nm, 100nm, 200nm, and 300nm) is successively formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The nonmagnetic interlayer 14 who besides consists of nickel-5at%Ta-20at%Zr of 5nm of thickness, the magnetic film A15 which consists of the Co-19at%Cr-12at%Pt-3at%B alloy of 15nm of thickness, the magnetic film B16 which consists of the Co-8at%Cr-22at%Pt alloy of 5nm of thickness, And the C protective layer 17 was formed one by one, and the medium N (-1, -2, -3, -4, -5) of the composition of drawing 6 (a) was produced.

[0065] The glass substrate 11 washed to the high-vacuum DC magnetron sputtering system was installed, Ta precoat layer 22 of 5nm of thickness was formed, the Fe-8at%Ta-12at%C film of 300nm of thickness was formed as a lining soft-magnetism layer B42 on this, and it heated at 400 degrees C. The soft-magnetism film of the structure in which the microcrystal grain of Fe deposited with this heat treatment was formed. As a lining soft-magnetism layer B42, a Co-Zr-X (X:Ta, Nb, Mo, W, nickel) system amorphous alloy film or an Fe-aluminum-Si alloy, a Fe-C-Y (Y:Ta, Hf, Zr, Nb) alloy, etc. can be used for others. The soft-magnetism film A23 which consists of a 80at%nickel-Fe film of 10nm of thickness, the 48at%Mn-Ir antiferromagnetism film 24 of 10nm of thickness, and the soft-magnetism film B25 which consists of a 80at%nickel-Fe film of 5nm of thickness were formed one by one on the lining soft-magnetism layer B42, it heat-treated among 300 degrees C and the magnetic field of 1kOe, and the magnetic-domain fixed bed 12 of the composition of drawing 6 (b) was formed. The solenoid type electromagnet has been arranged behind a substrate, it energized to this, the radial magnetic field of a disk was generated, and impression magnetic field strength was made small with the fall of substrate temperature. The anisotropy was given to radial [of a magnetic disk] by this processing. The lining soft-magnetism layer A41 which consists of Co-10at%Ta-2at%Zr of amorphous structure (10nm of thickness, 50nm, 100nm, 200nm, and 300nm) is successively formed on the aforementioned magnetic-domain fixed bed 12 in the same vacuum. The nonmagnetic interlayer 14 who besides consists of nickel-5at%Ta-20at%Zr of 5nm of thickness, the magnetic film A15 which consists of the Co-19at%Cr-12at%Pt-3at%B alloy of 15nm of thickness, the magnetic film B16 which consists of the Co-8at%Cr-22at%Pt alloy of 5nm of thickness, And the C protective layer 17 was formed one by one, and the medium O (-1, -2, -3, -4, -5) of the composition of drawing 6 (b) was produced.

[0066] The medium N (-1, -2, -3, -4, -5) produced by this example and Medium O (-1, -2, -3, -4, -5) were installed in the magnetic recording medium which sketched in drawing 3, and measurement comparison of the over-writing property when carrying out magnetic recording to the noise signal of the letter of a spike generated from the magnetic domain formed in the lining soft-magnetism layer 41 was carried out. The noise signal of the letter of a spike was defined as follows here. The direct current erase of the perpendicular magnetic anisotropy films 18 was carried out by the magnetic head, the signal of the shape of irregularity which has the signal strength of 1.2 times or more of the direct-current-erase noise level of the average detected by the reproducing head was made into the noise signal of the letter of a spike, and the number detected by per magnetic-disk round was compared. Moreover, the over-writing property recorded the signal of track-recording-density 300kFCI first, and carried out overwrite of the signal of track-recording-density 40kFCI on the same recording track. It erased, the ratio (N/S) of the remaining signal (N) and the signal (S) recorded later first recorded at this time showed the property worse than -35dB with x mark, and O mark showed the outstanding property. An example of a measurement result is shown as compared with Table 4.

[0067]

[Table 4]

媒体	裏打軟磁性層B	磁区固定層	裏打軟磁性層A Co-Ta-Zr	垂直磁化膜 磁性膜A/磁性膜B	スパイク信号数	オーバライト特性
N-1	なし	NiFe/MnIr/NiFe	10 nm	CoCrPtB/CoCrPt	0	×
N-2	なし	同上	50 nm	同上	1	×
N-3	なし	同上	100 nm	同上	2	○
N-4	なし	同上	200 nm	同上	4	○
N-5	なし	同上	300 nm	同上	8	○
O-1	Fe-Ta-C	同上	10 nm	同上	0	○
O-2	Fe-Ta-C	同上	50 nm	同上	1	○
O-3	Fe-Ta-C	同上	100 nm	同上	2	○
O-4	Fe-Ta-C	同上	200 nm	同上	5	○
O-5	Fe-Ta-C	同上	300 nm	同上	8	○

磁性膜A : Co-19at%Cr-12at%Pt-3at%B、膜厚 15 nm

磁性膜B : Co-8at%Cr-22at%Pt、膜厚 5 nm

[0068] The effect reduce the letter noise of a spike is large by considering as the composition which could suppress magnetic-domain formation in the lining soft-magnetism layer A arranged in the meantime, has arranged the antiferromagnetism film 24 in the position of distance 100nm or less from perpendicular magnetic anisotropy films 18 especially, and has arranged the soft-magnetism layer between perpendicular magnetic anisotropy films 18 and the antiferromagnetism film 24 by arranging antiferromagnetism film 24 in the lower layer of perpendicular magnetic anisotropy films so that clearly from comparison of Table 4. Moreover, by composition which has arranged the lining soft-magnetism layer B42 also in the lower layer of the aforementioned antiferromagnetism film 24, in addition to reduction of the letter noise of a spike, record efficiency can be improved and, as a result, an over-writing property can be improved. At this example, although explained using an example of material, such as a lining soft-magnetism layer, an antiferromagnetism layer, a nonmagnetic interlayer, and a magnetic film, the same effect can be acquired in any of other combination of said material.

[0069] [Example 5] One example of the magnetic storage by this invention is explained using drawing 3 . Magnetic storage consists of the suspension 33 which supports a magnetic disk 31, the magnetic head 32 for record reproduction, and the magnetic head, an actuator 34, a voice coil motor 35, a record regenerative circuit 36, a positioning circuit 37, an interface-control circuit 38, etc. A magnetic disk 31 consists of a vertical-magnetic-recording medium explained in the above-mentioned example, and lubricating film is covered on the protective coat. The magnetic head 32 consists of heads for reproduction which consist of a slider, the head for magnetic recording prepared on this and the magnetoresistance-effect type for signal regeneration, a huge magnetoresistance-effect type, a spin bulb type element, or a magnetic tunnel type element. The gap length of the magnetic head for record signal regeneration sets to 0.25 micrometers or less, in order to obtain the regenerative signal of a high resolution, and it may be 0.08-0.15 micrometers desirably. Any of a single magnetic pole type head or a ring-type head may be used for the head for magnetic recording. The width of recording track of the head for reproduction is made narrower than the width of recording track of the head magnetic pole for record, and reduces the reproduction noise produced from recording track both ends.

[0070] The magnetic head 2 is supported by the suspension 3. The medium noise figure of this example and record reproducing-characteristics evaluation were performed using this equipment. it was shown in Table 1 and Table 2 -- as - the vertical-magnetic-recording medium of this invention -- record -- resolution -- high-density record beyond :300kFCI can be realized, medium noise:8micro Vrms/mu Vpp in this density and the high-density property not more than error rate:10-6 are acquired, and a field recording density [50 Gb/inch / or more 2] magnetic disk unit can be constituted

[0071]

[Effect of the Invention] According to this invention, in any of the lower layer of the CoCr alloy perpendicular magnetic anisotropy films of high Cr concentration, or the upper layer Or the perpendicular magnetic anisotropy films which prepared the CoCrPt alloy magnetic layer with ultra-thin low Cr concentration and high Pt concentration are used for vertical both layers. By controlling the magnetic-domain structure of a lining magnetic layer by the magnetic-domain fixed bed, using the polycrystal nature thin film of amorphous materials or a non-columnar structure as a lining magnetic layer The suppression of an irregular magnetic domain and detailed-izing of irregular magnetic-domain size in the perpendicular-magnetic-anisotropy-films intermediaiton front face leading to a medium noise are attained, and the overly suitable vertical-magnetic-recording medium excellent in the stability of small record magnetization of a medium noise for high-density magnetic recording can be obtained.

[Translation done.]